THE
NAVIGATOR

NAV OF NOTE

Colonel Charles C. Barnhill, Jr.

The Air Force is extremely competitive. To succeed, every officer must do his job to the best of his ability. Your most important job is the one you have now. Set high standards for yourself and exceed them." These are the words of advice from Colonel Charles C. Barnhill, Jr., a man who has been attaining his goals for his entire career. Colonel Barnhill now is Commander of the 314th Tactical Airlift Wing, Little Rock Air Force Base, Arkansas.

Born in Brooklyn, New York, he enlisted in the Air Force in October 1961. After completing basic training, Colonel Barnhill entered the Aviation Cadet Program at James Connally AFB, Texas. In November 1962, he was commissioned a second lieutenant and received his navigator wings. Next, he was selected for Navigator Bombardier Training at Mather AFB, California. His first operational assignment was to the Military Air Transport Service (MATS), flying the brand new C-130 aircraft. Looking back, Colonel Barnhill recalls, "As with everyone fresh out of training, my first assignment was one of my most challenging. Luckily, I was helped in my learning experience by several of the more experienced aviators in my unit. This is the way it should be, the 'old heads' relating their experiences to the young guys as well as training them. In fact, we need more of that 'hangar talk' today."

From 1963 to 1969, Colonel Barnhill was assigned to the 1608th Military Air Transport Wing and the 437th Military Airlift Wing, Charleston AFB, South Carolina. During this time, he served as an instructor and flight examiner in both the C-130E and the C-141A aircraft. He was also Chief, Base Navigation School, Navigation Services Officer, and a Plans Officer in the Wing Combat Plans and Exercises Division. Recalling some advice he followed early on, Colonel Barnhill states, "For a young navigator, the first thing you must do is to get good at your primary job. My job was flying. I strove to become the best navigator in the wing, then the best instructor, and the best flight examiner. The excellent operational experience I gained there has served me well throughout my career."

Colonel Barnhill served with the 361st Tactical Electronic Warfare Squadron (TEWS), Phu Cat Air Base, Republic of Vietnam in 1971, followed by duty with the 362d TEWS at DaNang Air Base as a flight examiner in the EC-47 aircraft. Colonel Barnhill recalls, "In the EC-47, we were given an extremely complex job. Good crew coordination was absolutely imperative. I found this job to be a real 'navigator's mission.' We were up against a constantly changing scenario, inclement weather, and a determined adversary. Our successes resulted from hard work and a combined team effort. I'm really proud of the job we did."

Assigned to the 438th Military Airlift Wing, McGuire AFB, New Jersey from 1972 to 1978, he served initially as an instructor in the C-141A. Later, Colonel Barnhill was Chief, Airlift Management Branch; and Chief, Current Operations Division. "These were extremely rewarding and satisfying jobs for me. I was able to use my operational experience in a planning and management capacity."

In 1979, Colonel Barnhill served in the Pentagon as an Air Operations Officer, and as an International Political Military Affairs Officer under the Director of International Programs, Headquarters USAF. In 1981, he became the Chief of the Plans and Policy Division.

Reassigned to McChord AFB, Washington in November 1981, Colonel Barnhill was the Assistant Deputy Commander for Operations, 62d Military Airlift Wing. In August 1983, he became the first navigator to serve as Deputy Commander for Operations in a major MAC airlift wing. "It was very rewarding being associated with the 62d MAW. It is the only wing in the Military Airlift Command that flies both the C-130 and the C-141 aircraft, both of which I flew when they were fresh from the factory. In the course of any given day, these aircraft are flying throughout the free world, showing the flag, and supporting our forces and our allies."

Colonel Barnhill was selected as Vice Commander of the 314th Tactical Airlift Wing, Little Rock AFB, Arkansas, in June 1985. The 314 TAW is the largest tactical airlift wing in the United States Air Force. The primary units are four squadrons of C-130 aircraft, plus the 34th Tactical Airlift Training Group, the single training unit in the Department of Defense for the C-130. The Training Group annually trains over 2,500 crew members of the United States forces as well as those of over 30 allied nations.

A highly experienced navigator with 7,500 flying hours, Colonel Barnhill still maintains his tactical and formation lead qualification in the C-130E. "Leading a formation to the drop zone is still accomplished in basically the same way as when I started. Detailed planning and practiced navigational procedures are still the only means of getting into and out of the objective area. The Air Force mission will always be to fly, fight, and win. It is challenging, rewarding, and can be a lot of fun."

Regarding food for thought for the young officer, Colonel Barnhill advises that self motivation and discipline largely determine an officer's personal and professional effectiveness. Integrity is vital to becoming an effective leader. In his words, "You must apply the basic principles of honesty, courage, and conviction. Being an officer requires personal sacrifice to maintain our freedom and way of life. Whether it's strategic defense initiatives of the future or flying a C-130 into combat, we must have quality people or our weapons systems are worthless. Patriotism, loyalty and mission dedication continue to be valid concepts and we should never lose sight of these. I consider it a privilege and an honor to be in the Air Force and to serve my country."

FROM THE EDITOR

I'm easily impressed. I'm the kind of person who will look at the time and spend the next five minutes contemplating the marvels of my digital calculator watch. With the push of a button I have access to the date, day, time (two time zones), month, year, alarm setting, stop watch, and four math functions. All of this for the low price of $19.95.

Technology is growing at a faster rate every year; faster than our little minds can comprehend. In publishing a magazine, many technology-related documents come across my desk. This technology may not be designed or researched with the navigator in mind, but it will impact the field eventually.

Just recently I read a computer-oriented newspaper with an article about the next generation of medium for computer memory. Computers have gone from tubes, to transistors, to chips. Now bubble memory occupies a fraction of the space needed for a silicon chip and consequently works faster. But the latest of these revelations goes beyond bubble to organic memory. This chemically constructed living memory would make it possible to program at the near-molecular level. Talk has gone as far as the possibilities of reprogramming the memory of already existing life forms. This could lead to on-board computers for which you'd have to buy a flight lunch.

Other technological research is nearing us to a possible matter and antimatter propulsion system. Theoretically, with such a system, one gram of matter and antimatter could propel a manned spacecraft to Mars in less than a month. With conventional present-day methods, this trip would take about two years. Matter and antimatter release more energy than nuclear fission or fusion and produce no waste. I'm impressed.

Research allowed to go beyond the doubts and skepticisms determines our future. Before you return this magazine to the rack at base ops while awaiting the crew bus, *think*. Think of the changes that would take place today if the electronics on your aircraft weighed 1/100th of what they do now; if your aircraft needed, not thirty-thousand pounds, but only one gram of fuel to perform the mission. The changes that are taking place should impress us all.

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THE NAVIGATOR

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In the past year, the Statue of Liberty and the B-1B have made the headlines. Both are symbols of freedom. Lady Liberty has welcomed immigrants and stood for the American way of life for a century. The B-1B bomber represents this country's determination and resolve to maintain that level of freedom all Americans enjoy. In "B-1B: High Tech for a Low Profile," Major Butler gives insight into how the crews are selected and trained and some exceptional features of the weapon system.

Distribution: One copy per four navigators.

B-1B high tech for a low profile

Major Robert K. BUTLER
4018 CCTS
Dyess AFB, TX

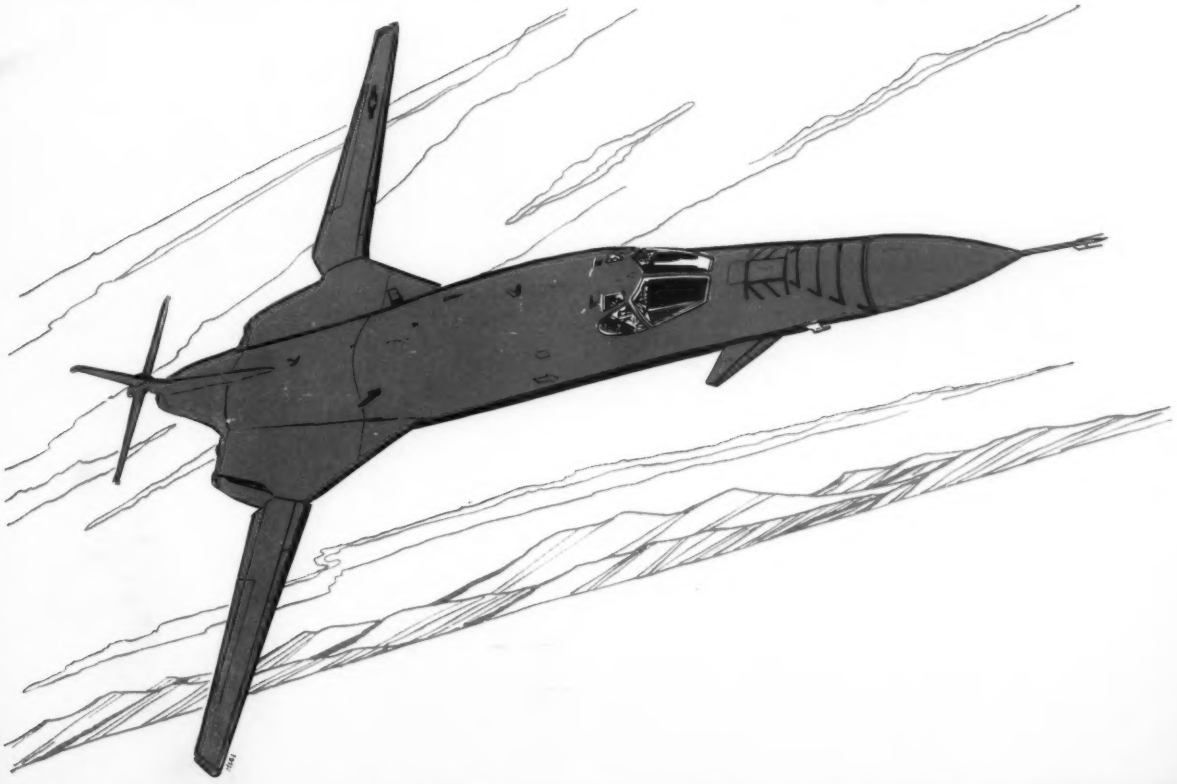
On 1 April 1985, the schoolhouse doors opened for the long awaited B-1B Combat Crew Training Squadron (CCTS). The first class was a mixed group of pre-selected 4018 CCTS instructors and staff, HQ SAC staff and a few other VIPs from assorted contractors and Mather AFB, California. Although the initial class was taught at Carswell AFB, Texas, because of courseware and instructor personnel availability, Dyess AFB, Texas is the 4018 CCTS permanent home. Before the schoolhouse opening, the 4235th Strategic Training Squadron at Carswell had been the hub of B-1B courseware development. The curriculum development started in early 1982. Long days and short weekends assured SAC it had the finest curriculum available for its newest and most ambitious weapon system in decades.

The Dyess AFB 4018 CCTS formed its first class in early January 1986. Previously, the new instructors were brought up to speed with updated courses, slides and associated logistics involved in running a CCTS. The 4018th schoolhouse and simulators (cockpit familiarization and cockpit procedures trainers) were in place late in 1985. The computer based instruction (CBI) will be the primary teaching tool and will eventually take over most of the courseware taught.

The computer equipment and courseware are some of the most advanced in the Air Force inventory. Touch screens and computer-managed instruction help guarantee the Air Force and SAC the best instruction, bar none. With the mature system, for the Defensive Systems Officer (DSO) the CCTS school will take 104 training days including 170 hours of classroom instruction, 104 simulator hours and 7 flights. The Offensive Systems Officer (OSO) training will be 106 days consisting of 194 classroom instruction hours, 110 simulator hours and 12 flights. Remember, this is a new training program and the numbers may change.

Pipeline students from Mather AFB will sporadically enter the system in late 1989. Until recently, SAC and USAF manpower personnel were drawing mainly from the B-52/FB-111 crew force.

For selection to the B-1B, minimum flight experience requirements for RNs/OSOs is 750 flying hours and 2 years in a SAC weapon system. A navigator with Offensive Avionics System (OAS) experience needs 500 total flight hours, 120 of which must be OAS time. For EWOs/DSOs, the requirement is 500 flying hours and 1 year in a SAC weapon system. Other recent changes



qualify navigators with 1000 hours in EC, RC, or KC 135s and EWOs from any command with 750 hours in the aircraft. Applicants must be an aircrew or staff member with an aviation service code indicating the individual is a "flyable resource." General requirements also include no negative quality force indicators.

If you would like to become a member of the 4018 CCTS at Dyess AFB, be prepared to start in the academic instructor ranks and eventually move to the flight line; just the opposite of Castle's CCTS. The Dyess operational bomb squadron crew members were selected last October. The aircrews for Ellsworth AFB, South Dakota were selected in November 1985. Grand Forks AFB, North Dakota and McConnell AFB, Kansas will have aircrew selections in June and October 1986, respectively.

The B-1B, truly a computer-age aircraft, is virtually mission dependent on computers. Offensive and defensive avionics, equipment status monitoring, electrical, fuel management and numerous other systems are powered by a battery of on-board computers. An immense memory capacity is available. NASA's Space Shuttle uses three IBM 101 computers for its missions while the B-1B uses eight of these same computers for its missions. The DSO and OSO jobs are done via five of these IBM avionics computers. Seven of the eight computers are loaded before each flight and are mated exclusively to a particular mission course line. The systems capabilities are virtually limitless. Using reprogrammable software, the operator can access the system to change and update or delete thousands of bits of information while airborne. As an example of software capabilities using the computer generated graphics, the systems can back up a malfunctioning switch on almost any panel in the aft station. The computers also allow access of OSO data and radar imagery on the DSO's computer screen. This ability to access either station's equipment allows responsibilities to be continuously shared. With all the advanced technology involved in the aft stations, the airplane opens a whole new world of responsibilities and equipment usage concepts.

Using the ALQ 161A Countermeasures System, the DSO has numerous state-of-the-art ECM features including reprogrammable threat software, electrically steerable phased-array antennas, pulse-to-pulse threat analysis and a tail warning system tied to the automatic expendables equipment. Coupled with an extremely small radar cross section (1/100th of the B-52), the B-1B and the ALQ-161A will be a formidable team for penetrating any type of enemy defenses for decades to come. The OSO, sitting to the right of the DSO, handles navigation, weapons release and stores management. The OSO's avionics center around a system similar to the B-52's offensive avionics systems (OAS). The radar has a phased-array nonrotating electronic scan--an enhanced version of the F-16's scan. It builds a high resolution stationary radar picture of a selected area (patch) by taking up to four "snapshots." This concept helps assure ease and accuracy of crosshair placement. The bomb nav and stores management panels perform unbelievable tasks in assisting the crew to navigate from point to point accurately and effortlessly. The OSO can then direct an assortment of weapons with pinpoint accuracy.

Several other new and innovative hardware goodies are in the airplane. The electrical multiplex (EMUX) system runs the aircraft electrical systems with a series of mini-computers and four fuselage length wires that electrically connect the back and front of the aircraft. This power-managed system uses time shared command signals to either activate or deactivate systems. In an emergency, the EMUX will also power down certain systems using a preprogrammed prioritized software list of non-essential equipment. Another advancement is the oxygen system which generates its own oxygen by a denitrogenation process of the RAM air. The Molecular Sieve Oxygen Generating System also filters and regulates the amount of oxygen being supplied automatically to the crew and avionics compartment. The Central Integrated Test System, a remarkable outgrowth of Edwards technology, immediately tells the crew if aircraft systems are functioning properly, degraded or failed. It also tells the crew member the corrective action needed for any particular malfunction. There are many more new and amazing systems too numerous to mention in this article. Suffice it to say, the B-1B is full of some of the best ideas technology has devised in recent years.

The operational capabilities of the B-1B are still being tested and evaluated at Edwards AFB, California, but those few who have flown in the airplane say it is a true joy. When the first B-1B arrived at Dyess it was put to the test seven days a week for both operational and maintenance training. As the Air Force received more airframes, the flying program kicked into high gear. Just watching the B-1B fly is spectacular! The first high-speed low altitude fly-over of Abilene and Dyess AFB on 29 June 1985 signaled the start of a new era in strategic defense with one of the most exciting weapon systems acquisitions in recent Air Force history.

In 1972, Maj Butler graduated from Texas Tech University. He completed UNT, EWT and CCTS before assignment to Fairchild AFB in the B-52. Next came assignment to Mather AFB, followed by Carswell AFB. Maj Butler now serves at Dyess AFB.

POLAR NAVIGATION

First Lieutenant Patrick A. POPE
325 BMS
Fairchild AFB, WA

So, you wear navigator wings? In coming years you'll see more emphasis on "systems operators," but you'll still need to demonstrate navigation skills. After advanced nav, we tend to forget polar navigation--one of the biggest challenges for a navigator. You may think you'll never use polar navigation, but you need to know a few things in case you ever go near the pole.

I flew to the North Pole recently during Global Positioning System testing at Fairchild. In the B-52 providing back-up navigation to the test aircraft, I spent most of the 13-hour flight integrating every available aid. Being the sole source of navigation information independent of the test equipment, I had to be prepared to say more than "Go South" if the equipment malfunctioned.

The key to a successful polar flight is preparing for the special problems of high latitude navigation. Study the flight profile and anticipate any unusual situations you may encounter. If you study some of the techniques unique to polar navigation you'll be able to stay ahead of the airplane.

One of the first problems you'll encounter is the old transverse mercator chart. It has some characteristics that could make it confusing. With a grid convergence factor of one, remember to add your west longitude and subtract your east longitude when converting true to grid. Also, you have a transverse mercator correction graph in AFR 51-40 that will provide you some critical corrections for the bending meridians, especially in the 60 to 80 degree range.

Review your aircraft's equipment to determine how polar flight affects it. If you think you can count on the radar to keep you on track, you've forgotten about arctic reversal and the constantly changing ice cap. Arctic reversal is ice returning radar energy much like any land mass. It causes coast lines to look like river trends. Thus, interpreting the radar properly requires very close concentration. The ice cap is constantly shifting with the seasons, which complicates accurate radar fixing. Determine where you will transition away from the radar scope and concentrate on other methods of navigation.

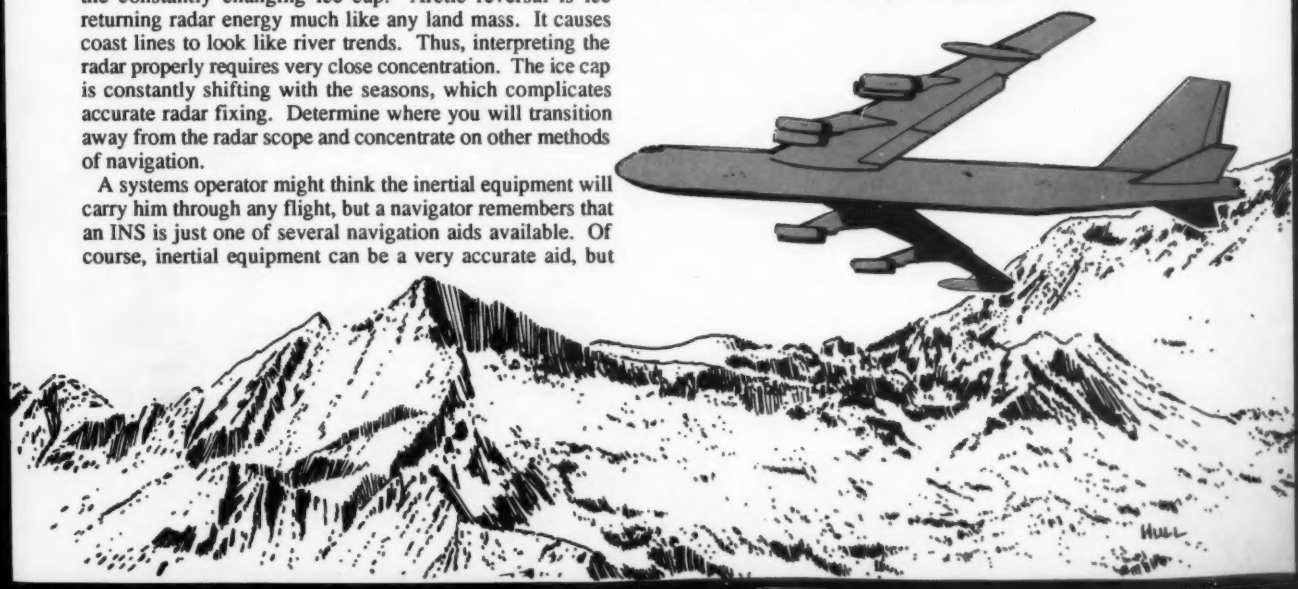
A systems operator might think the inertial equipment will carry him through any flight, but a navigator remembers that an INS is just one of several navigation aids available. Of course, inertial equipment can be a very accurate aid, but integrate it with celestial, and dead reckoning. As a navigator, you determine the plane's location.

Decide on a plan for aligning your INS, but be willing to let the equipment "ride." Don't waste all the hard work you put into a good alignment by inserting a bad fix. Know the updates available on your route and decide where you need to fix and where you should leave the INS alone.

Your compass is still a primary navigation aid but do you know what may happen to your heading system when you cross into high latitude? It's a fact of nature that a compass is adversely affected as it approaches a magnetic pole. Thoroughly review the heading system in your aircraft, as well as procedures for DG operation and precession correction.

Do you have a game plan to keep your compass accurate? Heading management is the cornerstone to accurate polar navigation, and your ability to care for the compass will determine the success of your flight. By the time you reach 80 degrees you should have an accurate correction for precession. Once you get farther, don't adjust your gyro unless absolutely necessary. An exact position becomes critical in computing an accurate heading check near the poles. You're better off carrying a precession correction than resetting your compass with inaccurate information. Pay close attention to your heading management, because small mistakes in your heading will multiply into larger errors in position and heading later.

The Zn graph is a handy aid for heading management. On a piece of graph paper, label one axis "time," the other "Zn." Compute Zns for whatever interval of time you like, plot the points, and connect the dots. Using 12 minutes as a time interval keeps the graph accurate, and even the midtime Zn will be off by no more than two tenths of a degree. The Zn graph is accurate as long as you're on time and on course. If you're neither, take time to compute an accurate Zn.



When planning your polar flight, you may wonder where to look for high latitude navigation techniques. Many Air Force documents, such as AFR 51-40 and SACP 55-10, Vol. I, provide a lot of vital information to the polar flier.

Your Air Almanac has a wealth of helpful information in the appendix . For instance, the Almanac says the pole can be used for an assumed position--just use the GHA as your Zn and the declination as your Hc for a quick precomp. The Almanac has critical information on polar sky diagrams and temperature corrections for refraction. If you use the Almanac just for precomp information, you're disregarding very helpful information lying right at your fingertips.

One of the best places to look for polar nav techniques is your own base. Ask for advice from the more experienced navs in your unit. That goes especially for you bomber types--the tanker navs have a lot of experience in polar navigation they'd be glad to share with you.

Once you're headed for the polar regions, it's up to you to ensure a successful and safe flight. If you do your homework, you'll enjoy it and be ready to handle the unexpected. The key is to be thoroughly prepared so you won't be surprised. Take time to periodically review your polar procedures, even if it means just a few minutes every time you go in for EWO study.

As a navigator, the crew counts on you to know where they are and when they'll reach their destination. A systems operator can do the job as long as the systems are working, but a proud navigator is prepared to navigate anywhere in the world--regardless of the system's status. Don't wait until you're at the top of the world to worry about getting back home.

Lt Pope graduated from Davidson College in 1981 and entered the Air Force via OTS. In 1983, he completed UNT and NBT. Lt Pope currently serves at Fairchild AFB.

Celestial Without the Air Almanac

Captain Robert L. GORDON
450 FTS
Mather AFB, CA

Lt Newguy is on his first trip out of the local pattern at Little Rock. He and his crew just finished dropping Army Special Forces troops at Podunk AAF on the East Coast. Returning to their rooms, they find a message from the Command Post. A quick phone call reveals Lt Newguy and crew are refragged to Lajes. Lt Newguy has a sinking feeling as he remembers the Air Almanac he *didn't* check out before leaving Base Ops.

You wouldn't knowingly leave your Air Almanac in Base Ops just before leaving on a 10-hour overwater mission, would you? But what would you do if you got to the departure point, opened your nav bag and found it missing? Or today's page was gone? This article outlines procedures you can use to shoot cel using just the HO Pub #249 volumes if you're ever in this situation.

Both methods involve extracting a series of corrections to a basic value from a set of tables. With a little practice, the night celestial extraction can be done in about 1 minute and the day celestial in 3 minutes. The day cel values can be calculated from 1965-2000, while the night cel ranges from 1980-1989 (five years either way from the Epoch year). These tables are found in the HOs immediately following the tabulated celestial data.

Let's start with the day cel since it's more complicated. Suppose we want to find the GHA and Dec of the sun for 16 April 1986, at 0415Z. Let's see, that shouldn't be too hard...

STEP 1. Round off your precomp time to the nearest whole hour. In this case, it is 0400. Then enter Table 4a in the HO 249, Vol II or III, with the year to find the hour correction "h" (in hours). Using 1986 for the entering argument, the value for "h" is +2 hours. For leap year calculations, two values are listed. One is to be used before and the other after 29 February.

STEP 2. Add the whole hour and "h" correction, changing days if the result passes through 2400 hours in either direction. The result is the Orbit Time, and is the entering argument for Table 4. For our problem, the orbit time is 0600Z, 16 April 1986.

STEP 3. Using the month and day from the Orbit Time, enter Table 4 to find "E," a base line value for GHA; "diff," the difference between our value of "E" and the next highest value; "Dec," the baseline declination for our problem; and "diff," the difference between consecutive values of Dec. The example answers are: E=05.00, diff=+04, Dec=N09-55 diff=+22.

STEP 4. Use the "diff" value for E and Dec and the number of hours from the orbit time (06) to enter Table 4b. The entering arguments for the table are interchangeable, similar to the d-Dec table found elsewhere in the HO 249. Entering with +04 and 06 gives a value of +01, and entering with +22 and 06 gives a value of +06. The correction takes the sign of the "diff" value. Combine the corrections with their original values:

05-00	N09-55
+01	+06
05-01	N10-01

The declination is finished.

STEP 5. Enter Table 4c with the original hour and whole 10 minutes rounded down (4+10) to find yet another correction. Write this value (237-30) under 05-01. Enter Table 4d with the remaining odd minutes to find the final correction. Write this value (1-15) under the last correction and add the three to get the GHA of the sun. Use critical table rules for Table 4d (left or up, whichever is appropriate).

05-01
237-30
1-15
243-46

This is the final value for GHA. Comparison with the Air Almanac gives encouraging results.

Our GHA 243-46	AA GHA 243-45.9
DEC N10-01	DEC N10-00.1

Calculations for night cel are much simpler. For the LHA of Aries, add the corrections for year, day/hour, and minutes to get the solution. The tables for Aries are on pages 320-321 of the Epoch 1985, Volume I, HO 249. For example, let's find the GHA of Aries for 0317Z, 13 May 1986.

STEP 1. Enter Table 4a with year and month, extracting GHA of Aries in degrees and minutes. As stated at the top of the table, the value is for the first day of each month, and additional corrections for day/hour/minutes will be added.

LHA Aries 218-38

STEP 2. Enter Table 4b with day (across the top), and hour (down the left side) to get the second correction.

Correction 56-57

STEP 3. Enter Table 4c to find the correction for minutes and seconds (if needed).

Correction 04-16

STEP 4. Add the three values to find the GHA of Aries for the example time.

218-38	From AA 0310Z	278-05.2
56-57		1-45.0
04-16		279-50.2
279-51		

This system may not be fast enough for everyday missions, but if an emergency should arise, you'll always be prepared.

Capt Gordon graduated from the Air Force Academy in 1979. He completed UNT and spent the following four years in the C-130 at Little Rock AFB. Capt Gordon now instructs night celestial at Mather AFB.

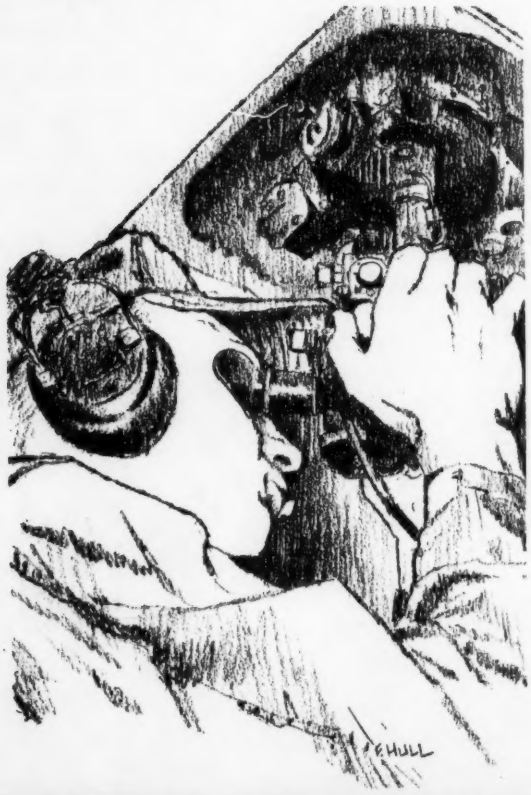
estimating CELESTIAL motions

Captain William J. RIGGLE
4017 CCST/CTOAR
Castle AFB, CA

"Nav, Cel, I cranked in your data and the only star I see is 2° low."
"Radar, Nav, crosscheck my celestial motions and make sure I didn't get the signs wrong."

OUTCOME: Celestial Navigation—unreliable—motions grossly in error. Judgment—unreliable—not only woke the Radar Navigator but expected him to remember how to compute celestial motions.

Sound familiar? Read on and learn how to quickly and easily estimate celestial motions. First I'll give an in-depth analysis of the formulas for celestial motions. Then, with an understanding of the mechanics of the formulas, I'll apply a simple technique to estimate both the motion of the body (MB) and the motion of the observer (MO).



Analysis of Celestial Formulas

Both celestial motions, MB and MO, are based on the rudiments of trigonometry—a sine wave and a cosine wave; the difference being in the amplitude or height of each wave. For example, a normal sine wave or cosine wave has an amplitude of 1 (see Fig 1). However, each celestial motion has a multiplier to its sine/cosine wave that increases its height.

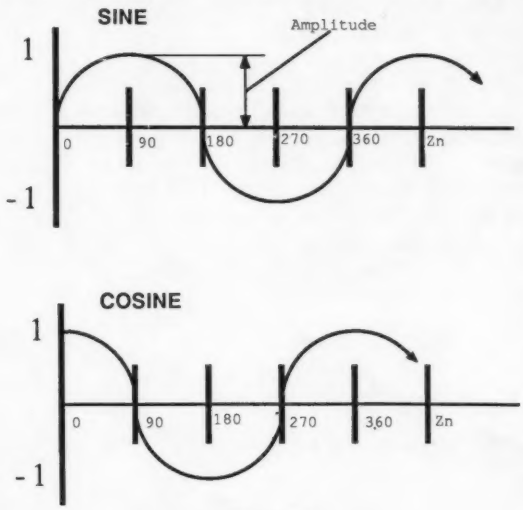


Figure 1

For motion of the body: MB = 15x COS(Lat)x SIN(Zn). The SIN(Zn) is the basis of the formula and changes with the Zn of each celestial body used. The 15x COS(Lat) stays constant throughout the normal three celestial observations of the precomp and therefore determines the height of the basic sine wave. Note that MB has its greatest potential value of 15 when we're at the equator (Lat = 0) and its smallest potential value of zero when we're at the poles (Lat = 90). Therefore, a plot of MB = 15x COS(Lat) x SIN(Zn) looks like Figure 2—a normal sine wave with the maximum amplitude determined by the current latitude. For example, if we're at Minot AFB (Lat = 48N) and looking due East at the rising sun (Zn = 90°), we would expect the sun to have its greatest motion of 10.

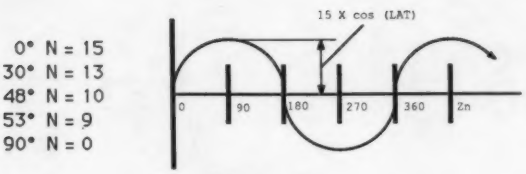


Figure 2

For motion of the observer: MO = GS/60 x COS (TC - Zn). In this equation, (TC-Zn) represents the "relative track" of the aircraft to the azimuth of the body. The COS(TC-Zn) is the basis of the formula and changes with the relative position of the body observed. GS/60, or groundspeed in miles per minute, should stay constant throughout the shooting schedule and therefore determines the height of the basic cosine wave. Note that MO has its greatest value when the body is off the nose or tail of the aircraft (TC-Zn = 0° or 180°). Likewise, it has its smallest value for bodies off the wings (TC-Zn = 90° or 270°). Therefore, a plot of MO = GS/60 x COS(TC-Zn) looks like Figure 3—a normal cosine wave where the maximum amplitude is determined by the current GS. For example, if we're flying at 420 GS shooting the sun off the nose of the aircraft (TC-Zn = 0°), we would expect to have the greatest motion toward the body: MO = 7.

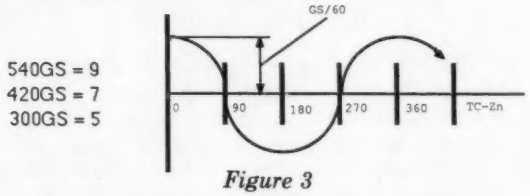


Figure 3

Estimating Celestial Motions

Armed with this explanation of the formulas for the motions, I'll apply a simple (to perform) technique to estimate both MB and MO. I say "simple" because the plotting graph is provided on the Celestial Precomp Form 289; the Star Selection by Azimuth Diagram (Fig 4).

First I'll cover motion of the body. Referring to Fig 2, notice that MB equals zero when the Zn of the body is either 0° or 180°. Using Fig 4, draw a vertical line from 0° through 180°, then draw parallel lines that are touching the outside of the circle, and finally draw vertical lines halfway between each. The middle and outside lines represent the minimum and maximum values for MB. To determine the motion of a particular body, picture the body at its appropriate position on the azimuth circle. Then estimate a value based on the position of that point on the circle relative to the lines drawn across the diagram. For example, we're on a nav leg over Castle AFB (Lat = 37); therefore, 15 x COS(Lat = 37) = 12. We label the outside lines as 12, the inner line as 6, and the middle line as 0. A rising or setting body at 90° or 270° has its greatest motion of 12; whereas, a body in transit, passing 0° or 180°, has zero motion. It follows then that a body at 30°, 150°, 210°, or 330° has a motion of 6. And any intermediate position of the body can be estimated just as easily.

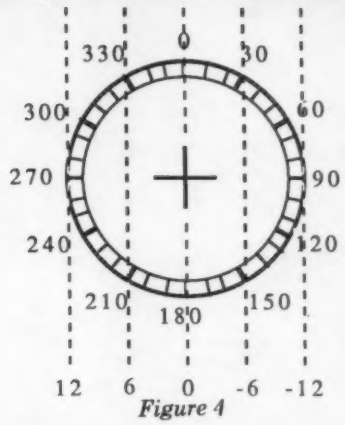


Figure 4

So much for the magnitude of the motion, but let's not forget *the most important thing*—the appropriate sign. Because we use an early shooting schedule, we must reverse the sign of the formula: MB = -15 x COS(Lat)x SIN (Zn). Therefore, we must label the East as negative (-) and the West as positive (+).

Next, I'll cover the motion of the observer. As stated before, MO equals zero when the body is off the wing of the aircraft; 90° left or right. Because this motion depends on the relative position of the body, the true course of the aircraft must be drawn in first. (Use the '+' sign in the middle of the circle to represent the tail of the aircraft.) Then draw lines perpendicular to this course to represent the maximum and minimum values for MO. For example, we're flying at 360 GS; therefore, (GS = 360)/60 = 6 (Fig 5). On a course of 210° we label the outside lines as 6, the inner lines as 3, and the middle line as 0. A body off the nose or tail has MO = 6, bodies off the wings have zero MO, and bodies 60° left or right of the nose or tail have MO = 3.

Again, the appropriate sign is *the most important* thing. And again the signs must be

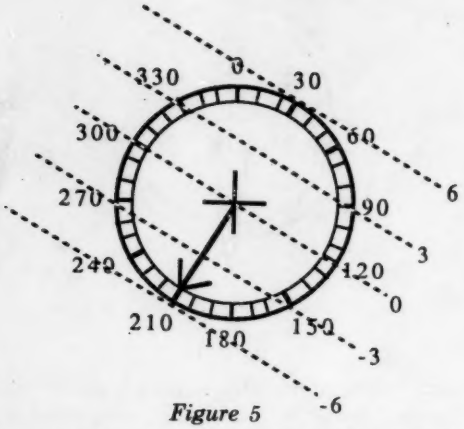


Figure 5

reversed because of the early shooting schedule: MO = − GS/60 x COS(TC-Zn). Therefore, we label the front of the aircraft as negative (-) and the tail of the plane as positive (+) [Notice the diagram already has the tail labeled with a '+'].

Applying the Technique to Estimate Motions

Let's apply this estimating technique in a practical example (refer to the check list example). I'm on a basic night celestial grid nav leg: Lat = 43, GS = 420, TC = 052°. The three bodies I'll be shooting have true Zns of 071°, 178°, 296°.

1. Start by labeling the East side of the Star Selection Diagram as negative. Then plot the three true Zns.

2. Next, using vertical lines and a scale of 11 (because Lat = 43), estimate MB for each body. MB1 = −10.5, MB2 = −.5, MB3 = + 9.

3. Now draw in the TC of the aircraft.

4. Using perpendicular lines and a scale of 7 (because GS = 420), estimate MO for each body. MO1 = −6.5, MO2 = + 4, MO3 = + 3.

5. Finally add MB and MO for a one-minute early total motion (TM) adjust: TM1 = −10.5 + −6.5 = −17; TM2 = −.5 + 4 = 3.5; TM3 = 9 + 3 = 12.

For comparison, here are the actual motions

STAR	MB	MO	TM
1	−10.37	−6.62	−16.99
2	1.38	4.11	3.73
3	9.86	3.07	12.93

CAUTION: Everything plotted on the Star Selection Diagram must be plotted in true as the diagram is in North up. We normally figure our motions on the MB-4 computer in grid.

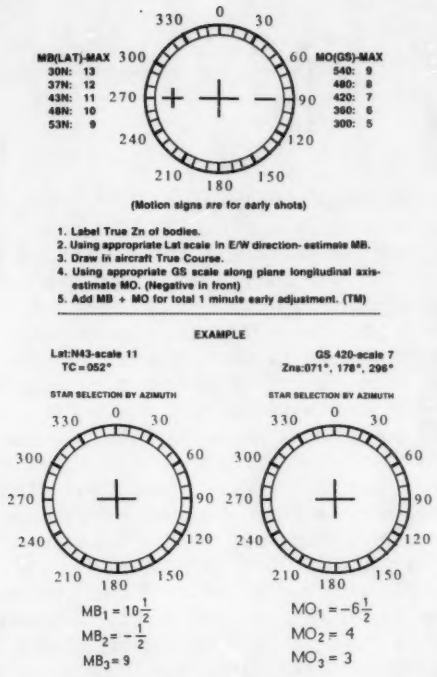


Figure 6

Applying the Estimate

REMEMBER, you are merely trying to estimate the motions involved. Hopefully, by understanding the mechanics of the motion formulas and applying this estimating technique, you will correct the gross errors. This technique can be used as a crosscheck of your MB-4 computer or handheld calculator motions. Used properly, you can catch wrong sign motion errors, motion errors greater than 2, etc. Best of all, you need no batteries or memorization as a check list is provided (Fig 6).

Capt Riggle graduated from Valdosta State College in 1975 with a degree in Mathematics. In 1977, he completed UNT and NBT and then was assigned to Barksdale AFB. Capt Riggle currently serves at Castle AFB.

Airdropping Navy Seals

Major Richard H. ORPHEUS
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Westover AFB, MA

I am, in my humble opinion, one of the world's greatest navigators. Granted, I haven't memorized my dash-one or 55-130, but I have logged over 5,000 hard C-130 hours and done every conceivable type of C-130 mission. I've flown low level/drop missions from Europe to Panama, recon in Southeast Asia, and Red Flag-CAT training. My ongoing drop CEA is so low I can no longer con any of the other 'gators into betting on drop scores.

Given this inflated image of my navigational skills, it was a great shock this past summer, when a "piece of cake" Navy Seal drop proved more difficult than forecast. "There I was" in the dark off the New England coast, at the end of a hazy summer day, with a novice Navy Safety Observer, trying to pick out the target ships from what seemed like half the North Atlantic fishing fleet. To make a long story short, we made the drop and the jumpers reached their target but it was not the "duck soup" effort we envisioned at the start of the evening.

Not prone to let such an outstanding reputation be forever tarnished by one less-than-perfect mission, I scheduled myself on the same mission the following night. That night, I not only aced the drop, but also discovered a number of reasons why the initial mission did not go smoothly. Perhaps more importantly, I began to understand joint service operations and how to approach them.

In Joint Airborne/Air Transportability Training (JA/ATT) missions, the Air Force supplies the airlift to either the Navy or Army. Because the user funds these missions, they are actively sought by the Guard and Reserve which have otherwise limited budgets. After a number of JA/ATT missions, including the recent Seal drop, I am convinced a "handle with care" label should be on the mission folder. This would caution crews that

these missions are more involved than normal operations.

Most aircrews have become accustomed to operating in a highly structured environment. We fly local missions with canned routes, take part in exercises which have been heavily preplanned, or deploy with a support and operations staff to coordinate details. On a single ship JA/ATT mission, however, you may find yourself in a different environment on your own interacting with an Army or Navy counterpart who has neither familiarity with nor appreciation of your needs or requirements. Concepts important to you, such as runway stress factors, taxi clearance, or even crew rest may have no significance to your contact and have probably not been considered in his mission planning. You may have to act as your own command post or ops officer in structuring the mission, overcoming lack of information, and approving or disapproving user requests.

You will organize your role in the mission, ferret out all the information you need specific to your Army or Navy counterpart and determine each person's action in accomplishing the mission. After you've flown the first mission, you'll usually uncover any problem areas and discover the techniques that'll make it run smoothly. It's ironic but the lessons learned on these JA/ATT missions are rarely retained and passed along. And, the next crew in, often from a different unit, must start from scratch. This article, therefore, is an effort to preserve some helpful techniques on dropping Seals. Naturally, the mission breaks down into two phases--planning and execution.

PLANNING

Although there are no published procedures on dropping Seals, Chapter 26, 55-130, "NEADS" gives guidance on dropping equipment at sea and some good background for this mission. Your initial meeting with your Navy contact, be he an on-board safety observer or ground liaison, is the all-important first step. At this meeting, you need to coordinate specific items.

RUN-IN - Unlike a ground DZ, the drop zone ship(s) will face and run into the wind. Wind direction will therefore determine DZ axis, run-in heading, racetrack orientation and even the route. It's helpful to bring the latest forecast winds in the drop area so you and your contact can estimate the run-in direction.

DZ - Your contact should, of course, brief you on the location and configuration of the ships (Fig 1). Beyond this, determine the size, location and relationship of all ships involved. (For example, "Single large ship/DZ or large mother ship 2 nm north with two small DZ ships.")

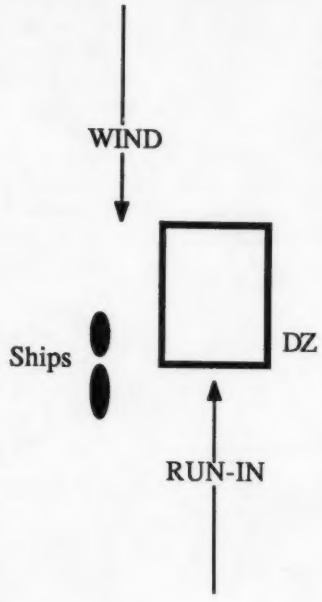

Figure 1

THE SAFETY OBSERVER - It is crucial to have the on-board safety observer positively identify the ship. Stress this point and specify when and how you want this assistance. As a minimum, the safety observer should confirm the target (1) initially, (2) at the dry pass, and (3) at the one-minute warning.

COMMUNICATIONS - Obtain the DZ frequency, call sign and any other communications that might be used (i.e., smoke or flares). Review the procedures that will be used by the ship to notify you of any no drop condition. If properly identifying the target ship might be a problem, recommend a flare from the target at the one minute warning. (If time permits, review with ATC Center, via a land line, when, where and what your activity will be. This may eliminate the need to explain your intentions in detail while you're enroute.)

DROP SCENARIO - Finally, review the how and when of the drop. The focus, of course, will be the desired TOA. Usually the team will request a dry pass sometime prior to the actual drop. An ideal sequence is: (1) Initially identify the ships and DZ just before the 20 minute warning and go into a 10 minute racetrack, (2) Return for a dry pass at 500 at the 10 minute warning, and (3) Repeat the procedure for the actual TOA. The form in Fig 2 may help you compile this information.

WX: w/v _____ Ceiling _____

COMM: freq _____ ID " " _____

LOCATION:

N _____ W _____

Radial/DME _____

freq _____

SEQUENCE		DROP INFORMATION	
Start Eng	_____	Dry Pass	
T.O.	_____	Altitude	_____
E.T.E	_____	Airspeed	_____
ID Ship		Mag Course	_____
20 Minute	_____		
Dry Pass		ACTUAL DROP	
10 Minute	_____	Altitude	_____
6 Minute	_____	Airspeed	_____
1 Minute	_____	Mag Course	_____
TOA	_____		

Figure 2

EXECUTION

TAKE-OFF & ENROUTE - Don't shortchange yourself on time! Set up a hard take-off time and route that will allow you sufficient time to settle in, establish contact with center and take advantage of the available navaids. The best approach is to use the nearest VOR/TACAN radial and fly out the radial closest to the DZ heading. Once the ship has been identified, determine the exact radial and DME for future reference.

ALTITUDE - The ideal altitude for the final leg is 1,000' above the water. This permits use of navaids and identification of the target. Remember, the possibility of identifying the ship decreases rapidly above this altitude.

RADAR - This tool is extremely helpful in locating the DZ, especially if the target is a large ship.

OVER THE TARGET - Once you identify the ships, set up a racetrack pattern that will give you the desired timing and keep you in the vicinity of the ships (Fig 3). To depart the immediate area for timing just makes relocating the ships more difficult.

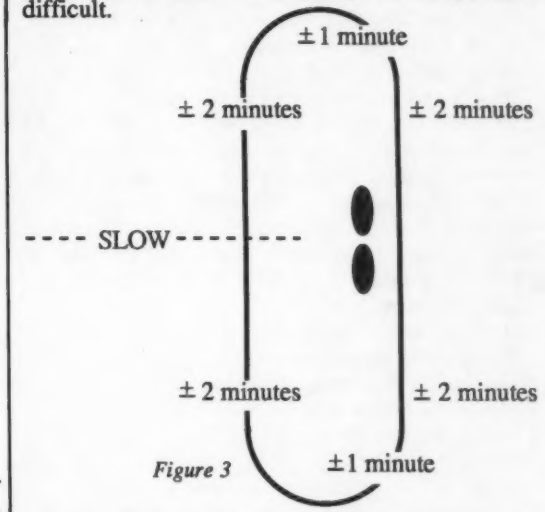

Figure 3

Normally, this is a fun mission unique from the low-level, ground DZ situations most "trash-haulers" fly. A daylight drop alongside a sizeable target ship is about the easiest drop you will ever make. But don't let the nature of the mission make you complacent about "covering the bases." Weather and visibility, late take-offs or any number of adverse circumstances can quickly make this mission much more difficult than it appears.

Maj Orpheus graduated from Holy Cross College and was commissioned via ROTC. After UNT, he flew in the C-130 at Pope AFB. Maj Orpheus currently is a Reservist at Westover AFB.

Captain William H. WRIGHT, Jr.
USAF/GAF Exchange Program
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GAFTIC

German Air Force Training in Canada

The Germans have landed! In Goosebay, Canada, the German Air Force conducts a rigorous low level training exercise called GAFTIC (German Air Force Training in Canada). As the USAF Exchange Officer at Hopsten AB, Germany, I've flown the F-4F in two weapons training deployments (WTD). As the only American stationed with the GAF 365th Tactical Fighter Wing, I see firsthand how our NATO partners conduct fighter operations. This is a very rewarding experience seldom available to USAF aviators. Add to this the scenario of a USAF fightergator flying with the Luftwaffe in Canada and you really have a unique situation. I've been impressed by what I've seen and I'd like to relate that experience. First, I'll discuss the background, the players and the syllabus. Then I'll move on to life support, bird strike potential, and visual cues. Finally, we'll look at how aircrew responsibilities are divided to provide maximum safety from natural and manmade hazards.

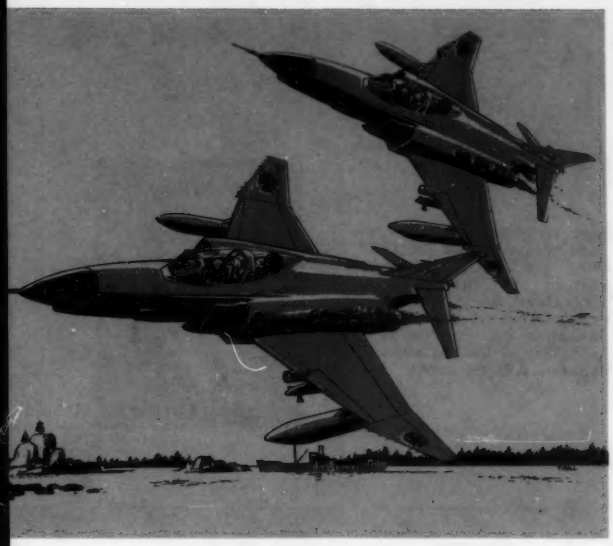
GAFTIC began in the spring of 1980 to provide a flying environment for realistic low level combat training. Europe, because of its dense population, is not suitable for such training. The Canadians have provided an ideal environment in northeast Canada, a place called Goosebay, Labrador. Unlike the European continent, Goosebay is sparsely populated and one can fly low and fast without evoking the usual noise complaints. The realism begins every morning with an intelligence briefing describing a simulated combat situation. The flying area is about 400 miles long and 150 miles wide. It's covered with a thousand lakes, tundra, forests and mountains. The varied landscape provides its own realism. This exercise sharpens low level flying skills and hones combat preparedness. As we know, it's all a matter of training.

The training syllabus is a basic step-down program with the first few sorties set at 500 feet AGL and 420 knots. Later flights are set for a minimum level of 100 feet AGL and a maximum speed of 540 knots. The pace is somewhat accelerated due to WTD time constraints so only experienced flyers (i.e., no new aircrews) are present. The key point, however, is always, "Don't go below your comfort level." And one's comfort level varies. You might be flying at 100 feet one day and feel good, but the next day you find yourself climbing in the turns--a sure sign of low altitude uneasiness. So climb up! Enough other preoccupations demand your attention so at least be comfortable with your altitude.

What are these other preoccupations? Flying in the north country entails considerable life support measures. In the winter and spring months an antiexposure flying suit (poopie suit) is obviously needed since temperatures are seldom above freezing. Flying with the poopie suit or Frankenstein (the name the Germans use) is another experience. It's not easily donned or removed. It is also not the most comfortable flying gear. It restricts movement. One sweats a lot. It is, however, the latest in vulcanized technology and does what it's intended to do--save your life in cold conditions.

In the summer months, everything that grows and procreates had better do so ASAP. This atmosphere generates determined and often tenacious wildlife. A good example is the black fly--a small, bloodsucking insect only deterred by industrial strength repellent. It looks harmless when it lights, but is a respected threat when you see one fly away with a hunk of meat formerly attached to your body. They fly in swarms and are a big threat to your well-being if you trap some in the cockpit or bail out into their midst. You're sure to be the center of attention.

Another winged threat is the bird. According to the Luftwaffe Internal Report #84112, which describes in detail the danger of birdstrikes in Labrador, bird formations are common in the spring and summer months if you're flying at altitudes up to 3,000 feet AGL. Up to 10,000



feet AGL, you may see Canadian Geese which can weigh 3,600 grams (about eight pounds). Large formations normally can be seen and avoided; however, a problem may arise when the birds fly singly or in pairs.

Visual cues is another tricky situation when flying low. The classic example is the ridgeline before the mountain on the horizon. Because of lighting, cloud cover or foliage coloring, the ridge does not stand out, is not observed, and is not avoided when mountain crossing is attempted. The F-4F is equipped with a radar altimeter with an audio low altitude warning capability. This helps in avoiding the rocks. However, if it's inoperative or the crew is otherwise unaware of the trees, the result could be--CRUNCH!

This brings the Search and Rescue (SAR) people into play. Before stepping to the aircraft, a map of the planned route is left with the SAR. The flights are always planned for at least a two ship. If only one aircraft takes off, the pilot must fly the planned ground track. This narrows the possible search territory and expedites the rescue. When flying low, these natural and manmade threats must be avoided to accomplish our missions. The threats are by far superior in number. For this reason, the aircrew must share responsibilities to adequately consider each threat. I'll describe the system the Germans used during GAFTIC.

Their system is a basic contract between the pilot and the weapon systems officer (WSO). The basis of this contract is trust. Months prior to the deployment, crews are chosen to fly together to build a foundation of trust. The formula is to pair an experienced with a less experienced aircrew member. This, of course, is an attempt to overcome the perennial problem of most teams--you are only as strong as your weakest link. The contract goes further in designating aircrew responsibilities.

The pilot must fly the jet to the mission objective. To do this, he first has to keep out of the rocks by constantly looking forward between 11 o'clock and 1 o'clock. For the most part he won't see his wingman or lead. Thus, he has to listen to the WSO who is giving a running commentary on formation, topography, navigational/speed corrections, and threat reactions. During the low level, the pilot sees the other aircraft in the formation only when the terrain changes (i.e. a valley) and a trail formation is required. In this case, he takes intercockpit control of the formation. When all goes well, the pilot performs his next duty as weapons actuator and fulfills the mission objective.

In the meantime, the WSO is busy with navigation, timing, formation, checking six and threat reaction. The WSO performs as a talking map, trying to talk the pilot's eyes on a prominent geographical feature (a lake with an island, a mountain with a sheer drop on one side, a tree hammock, a last-chance gas station, etc.). He does this ASAP so he can do other things. The enroute timing corrections are standard (whatever you use--ten percent, incremental or TLAR methods). Speed adjustments, however, are given as power adjustments (for example, throttle up/back four percent). This is done since the pilot cannot look inside the cockpit to monitor the airspeed but he can feel approximately what one percent of power is on the throttle. The WSO is also responsible for the formation.

If a heading correction is needed to maintain formation integrity, again since the pilot must keep his eyes out of the cockpit, instead of degrees of turn the WSO gives the command in seconds to turn. (For example, "We're slightly left of track, come right three seconds...rollout.") Because the WSO has the handle on the formation, he must frequently inform the pilot of the status, "The formation is left line abreast, 6,000 feet, ten degrees swept." The WSO also directs the comm-out turns. And not forgetting probably the most important measure for self-preservation, the WSO constantly checks six o'clock for bandits. If a threat is spied a defensive/offensive reaction may be required depending on the situation and the mission.

And the mission is what it's all about. There are many factors weighed against us. Natural threats such as weather, terrain and birds are ever present. Manmade threats evidence themselves as enemy aircraft, missiles or even power lines. It takes teamwork to be safe and survive. As a USAF representative with the Luftwaffe, I've had the unique opportunity to see how our NATO teammates conduct fighter operations. I've chosen to describe GAFTIC because it exemplifies how low level combat training can be thorough and safe. The German Air Force puts theory to use. GAFTIC pushes combat training to the limits, safely. I'm glad to have been a player.

Capt Wright graduated from Stetson University in 1975. After OTS and UNT, he trained in the F-4D at Homestead AFB. Next came assignment to the F-4E at Ramstein AB. Since 1984, Capt Wright has served at Hopsten AB, Germany.

Professional Reading

Major Donald W. RIGHTMYER
HQ TAC/SEP
Langley AFB, VA

An extensive professional reading program or study of American air power must include facts about our beginnings. We can trace back to the early roots of U.S. military aviation during the Civil War days but aviation came into its own as a viable weapon during the World War I years. Nearly 70 years have passed since the Great War's end, but some of the best books about World War I American aviation have just been published during the last five years.

Dr. James J. Hudson's *Hostile Skies: A Combat History of the American Air Service in World War I* (Syracuse, 1968) provides a quick overview of the development of American air units for the American Expeditionary Forces and their active participation in the war from April to November 1918.

Dr. Philip Flammer, a retired USAF officer, tells the story of 40 or so young Americans who fought with the French in the air before the U.S. entered the war. His book is *The Vivid Air: The Lafayette Escadrille* (Univ. of Ga, 1981) and it lays to rest many of the myths about that legendary flying group but takes nothing away from the importance of what those men did.

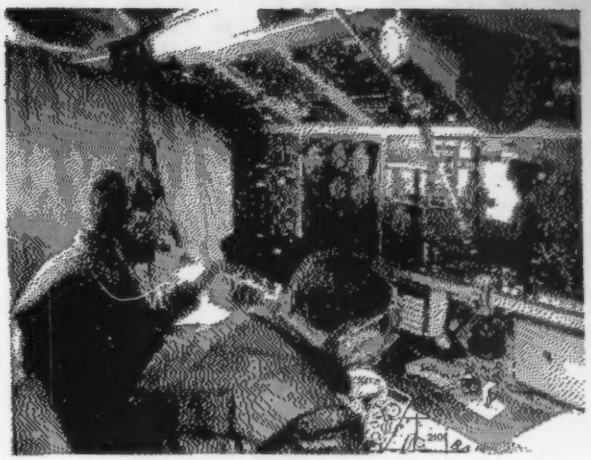
A four-volume history, *The U.S. Air Service in World War I*, was edited by Dr. M. Maurer and published in 1978. While essentially brand new, these volumes consist of a group of writings written immediately following the war. They include a history and final report on U.S. air activities in Europe during the war, early military aviation concepts, a detailed look at the air force in the battle of St. Mihiel and postwar review of all that went on. The illustrations alone will give you hours of entertainment, but the real meat lies in the "lessons learned" by the men who fought alongside Billy Mitchell and others.

One of the most recent books on World War I aviation is more international in nature, *Rise of the Fighter Aircraft, 1914-1918* (Nautical and Aviation, 1984) by Dr. Richard Hallion. He is a noted authority on the history of aircraft research and technology and this book provides an outstanding look at the very beginning of fighter pilots and their aircraft. Dr. Hallion particularly focuses on the technological evolution of aircraft and tactics.

One of the long-term products of the first air war was the early development of air doctrine based on the experiences of those who fought in it. All of us have heard of the classic work by the Italian air theorist Giulio Douhet, *The Command of the Air*. Its recent reissue in paperback as part of the USAF Warrior Studies series gives you the opportunity to read one of the early works that played a part in developing our air doctrine and strategic bombing concepts.

Even the most avid "canvas and wire" enthusiast won't plow through all of these during the next year. Choose one during 1986 and make this the year you learn a little about the folks who went "over there" and set the groundwork on which we continue today. Happy reading.

Turning the Corner



First Lieutenant Mark C. Dickinson
22 AREFS
March AFB, CA

Although navigation training programs and systems have enhanced our skills and abilities, dead reckoning (DR) remains the navigator's primary means of navigation. With a little practice and experience, everyone can DR from point A to point B with awesome results. However, when we must DR from point A to point B via an intermediate turnpoint, the results are not always as effective or predictable. "TLAR" or "WAG" work from time to time, but let's examine two more effective methods used to DR around a turnpoint--template turn and chord and bearing.

The template turn method is based on accurately plotting the airpath around a turnpoint, applying the best known winds, and plotting the resultant airplot DR. Start by determining turn diameter based on true air speed (TAS) and bank angle (Fig 1). Then, select a template circle with a diameter equal in scale to the turn diameter. Place the template tangent to the true heading (TH) into the turnpoint and lightly trace an arc. Now, draw the TH after aircraft roll out and calculate the air distance traveled during that time. Using dividers, arc off the calculated air distance and establish an airplot. Finally, apply best known winds to the airplot for the DR position. The template turn is fast and easy, but with the chord and bearing method you can accurately DR around a turnpoint without using a template.

The chord and bearing method of dead reckoning around a turn is based on plotting the effective airpath (versus actual airpath) from a turnpoint to a roll out point. A bearing and chord (distance) from the turnpoint are necessary to position an airplot at the exact time of aircraft roll out. Begin by calculating the number of degrees turned (the TH into turnpoint (TH1), minus the TH after the turnpoint (TH2)).

Figure 1

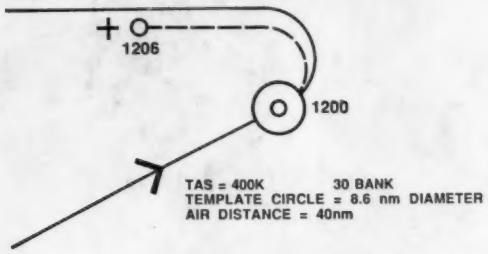
TEMPLATE TURN CHART

AIRPATH DIAGRAMS

TAS \ BANK ANGLES	30	25	20	15	10
300	4.3	5.3	6.8	9.3	14.1
310	4.7	5.8	7.5	10.2	15.5
320	5.2	6.4	8.1	11.1	16.9
330	5.6	6.9	8.8	12.1	18.3
340	6.0	7.4	9.5	13.0	19.7
350	6.5	7.9	10.1	13.9	21.1
360	6.9	8.5	10.8	14.8	22.5
370	7.3	9.0	11.5	15.7	23.9
380	7.8	9.5	12.2	16.6	25.3
390	8.2	10.0	12.8	17.5	26.7
400	8.6	10.6	13.5	18.5	28.0
410	9.1	11.1	14.2	19.4	29.5
420	9.5	11.7	14.8	20.3	30.8
430	9.9	12.2	15.5	21.2	32.2
440	10.4	12.7	16.2	22.1	33.6
450	10.8	13.3	16.8	23.1	35.1
460	11.3	13.8	17.5	23.9	36.4
470	11.7	14.3	18.2	24.9	37.8
480	12.1	14.8	18.9	25.8	39.2
490	12.6	15.4	19.5	26.7	40.6
500	13.0	15.9	20.2	27.6	42.0

Example 1

TEMPLATE TURN



LOG EXAMPLE

TIME	POS SYM	PRESENT POSITION	T.C. OR G.C.	W/V DC	T.H. OR G.H.	VAR OR %PREC CORR	M.H. OR AGYH	DEV	CH	TAS	AIR DIST.	DIST TIME	GS
1200	⊙	TURN PT	065	210/50 -3	060	-10	050			400			445
1200	A/H		210	210/50 0	210	-10	200			400			350
1200	+ ⊙	TEMPLATE 8.6 DIA 30 BANK		210/50						400	40	5 +06	

MISSION INFLIGHT

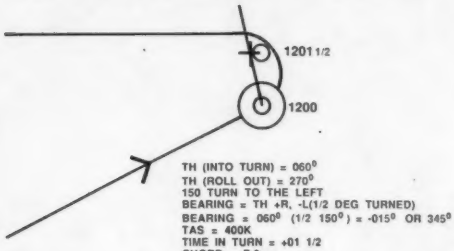
20 Calculate a bearing from the turnpoint (TH1, plus half the number of degrees turned right, or TH1 minus half the number of degrees turned left) and record TAS and time in the turn. Now calculate a chord using the MB-1 computer and the following procedure from SACP 55-10, Vol 1 (C1) 5 March 1975, page 75, Computer Solution (all airspeeds):

1. Find distance in turn (TAS x time).
2. Find diameter of turn (distance/degrees turned = diameter/115).
3. Put 360 degrees under index.
4. Place grommet on top line of grid.
5. Plot diameter straight down.
6. Rotate computer one-half number of degrees turned.
7. Read chord length as horizontal distance from plot to grommet.

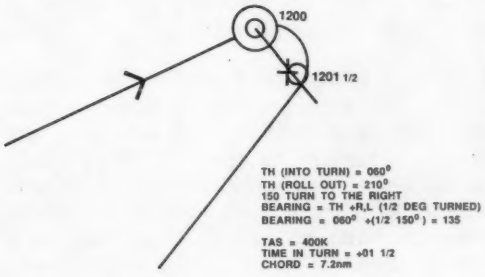
Next, position an airplot at the calculated bearing and chord from the turnpoint. The last action is to apply the best known winds to the airplot and plot the roll out DR position. At first glance, the chord and bearing method seems time consuming, but with practice it can be accomplished very quickly.

Example 2

CHORD AND BEARING - LEFT TURN


1201 1/2
1200
TH (INTO TURN) = 060°
TH (ROLL OUT) = 270°
150 TURN TO THE LEFT
BEARING = TH +R, -L(1/2 DEG TURNED)
BEARING = 060° (1/2 150°) = -015° OR 345°
TAS = 400K
TIME IN TURN = +01 1/2
CHORD = 7.2nm

CHORD AND BEARING - RIGHT TURN


1200
1201 1/2
TH (INTO TURN) = 060°
TH (ROLL OUT) = 210°
150 TURN TO THE RIGHT
BEARING = TH +R,L (1/2 DEG TURNED)
BEARING = 060° +(1/2 150°) = 135
TAS = 400K
TIME IN TURN = +01 1/2
CHORD = 7.2nm

LOG EXAMPLE

TIME	POS SYM	PRESENT POSITION	T.C. OR G.C.	W/V DC	T.H. OR G.H.	VAR OR %PREC CORR	M.H. OR AGYH	DEV	CH	TAS	AIR DIST.	DIST TIME	GS
1200	⊙	TURN PT	065	210/50 -3	060	-10	050			400			445
1200	A/H		210	210/50 0	210	-10	260			400			350
1201½	+ ⊙	CHORD/BEARING 7.2 NM/345°		210/50						400		+01½	

MISSION INFLIGHT

Both methods of dead reckoning around a turn are accurate and easy to use. Decide which method will work best for you. Use it to DR around those dreaded turnpoints and go for the proverbial "end nav shack!"

After Air Force enlistment in 1976, Lt Dickinson graduated from Park College via Operation Bootstrap. He was commissioned through OTS in 1983 and then completed UNT. Lt Dickinson now serves at March AFB.

GREENWICH-*where time began*

Captain Lawrence R. PRATT
41 ECS/DOFA
Davis-Monthan AFB, AZ

If you're ever in England, do yourself a favor and visit the Old Royal Observatory at Greenwich, southeast of London. It's pleasant, entertaining and historical. But, most of all, it'll give you an appreciation for the years of hard work and dedication that went into developing modern navigational capabilities.

GMT, GHAs and ZNs haven't always been with us. Someone developed these values to provide an accurate means of navigation. That "someone" turned out to be the English, commissioned by Charles II to research the determination of longitudes "for the perfection of navigation and astronomy." This was in 1675, when navigation applied to ships sailing outside the sight of land.

The Royal Observatory was founded in Greenwich to isolate observations from the city of London. A large park was built around the site to minimize the effects of the few nearby lights. Here the problems of determining longitude were addressed.

For some time, latitude had been relatively easy to determine. The fixed position of Polaris required only a simple celestial fix with minor adjustments. Determining longitude was a more demanding process.

The early observatory was the site for two key forms of research—developing reliable timepieces and determining longitudes. Because using the sun for timekeeping was inaccurate, the stars were used for time reference. Once this reference was established, work began on various chronometers. Numerous timepieces were developed in an attempt to insure accurate time over long durations, particularly on seagoing vessels. These chronometers also required stable platforms to counter a ship's pitch and roll, not unlike a current INS. After years of research and applied craftsmanship, acceptable standards were achieved. An extremely impressive selection of clocks, both past and present, may be seen in the Spencer Jones Gallery of the observatory.

To establish a system for determining longitude, an array of observation rooms was built. These numerous and varied rooms were fitted with quadrant and transit instruments for observing celestial motions. Used with accurate clocks, observers began gathering and recording data. After years of work, a provisional star catalog was published in 1712 and the first Nautical Almanac appeared in 1767.

Worldwide standardization of time and navigation began in the mid-1800s with the start of "railway time" throughout Great Britain. In 1884, an International Meridian Conference established Greenwich as the prime meridian and GMT as the worldwide basis for time. Selecting Greenwich was logical as 72 percent of the world's shipping used Greenwich as the prime meridian. Also, the North American rail system time schedules were based on GMT oriented time zones.

The 1930s saw the demise of Greenwich as a center of observation. The lights and smoke of London were encroaching on the area and the bombing of World War II forced the dispersal of the observatory's work. After the war, restoration was begun and Greenwich was progressively incorporated into the National Maritime Museum. One of the few working items still at Greenwich is a 28 inch refracting telescope, one of the largest of its kind in the world.

For a navigator going to England, a visit to Greenwich is a must. A few hours spent at the observatory can be an extremely pleasant and informative way to learn more about the beginnings of global navigation.

Capt Pratt was commissioned through OTS in 1974. After UNT, he was assigned to Norton AFB. Next came duty in the F-4E at Homestead AFB, Ramstein AB, and Luke AFB. In 1981, he was reassigned to Mt Home AFB. Capt Pratt now serves at Davis-Monthan AFB.

USAFA SIN:

STAFF INSTRUCTOR NAVIGATOR

Captain Nathan H. KRYS
HQ USAFA/DFEE
USAF ACADEMY, CO

Do you want to know about a rewarding, career broadening assignment? Are you a navigator trying to increase your knowledge inside and outside operations? A staff instructor navigator (SIN) position at the US Air Force Academy (USAFA) may be of interest to you. A SIN may work as an air officer commanding for an academic department within the Dean of Faculty, or in a staff position with either the Commandant of Cadets or the Director of Athletics. The Academy is one of the few places you can fly and still expand your career objectives outside of operations.

The Academy consists of three separate mission elements which are supervised by the Superintendent. The Commandant of Cadets is responsible for professional military training, flying programs, and the everyday duties of cadets. The Dean of Faculty is responsible for all academics leading to a bachelor of science degree. The Director of Athletics is responsible for the physical fitness of cadets, athletic programs, and intercollegiate sports. This article briefly explains cadet academic requirements, core navigation requirements, and the SIN's duties as a member of the faculty.

There are 30 SIN and 16 full-time navigator positions at the USAFA. The SIN positions (for flying duties) and the full-time navigators are assigned to the 50th Airmanship Training Squadron (50 ATS). This squadron is responsible for all aviation science courses dealing with navigation and aviation fundamentals.

All cadets must take a "core" curriculum in all subjects. The goals of all core courses are to nurture cadets' problem solving and communication skills, to give them a perspective on technology, and to enable them to use this technology for the benefit of the Air Force. A graduate will have completed 111 semester hours (most courses are three semester hours) in core courses alone and must take at least 24 hours more to receive a bachelor of science degree in Basic Academics. Cadets majoring in any of the 19 disciplinary majors (such as physical or political science) must take at least 33 hours over the core curriculum. To graduate, a cadet must also take 4 courses in professional military training, 12 courses in physical education, and a flight core course. The Aviation Science courses in navigation provide part of the mandatory core and offer elective courses in aviation throughout the academic year.

Most of the classroom navigation procedures are taught by 50 ATS instructor navigators. These instructors are full-time navigators who teach aviation science courses ranging from AV-100, an introductory freshman level motivational course, to AV-471 which prepares senior cadets for UNT. All navigation courses use the T-43A , the flying classroom. Mandatory for all freshmen cadets, course AV-100 offers a chance to visit operational bases within a few hours flying time of the Academy. The cadets observe how operational flying squadrons, civil engineering, aircraft maintenance, security police, air traffic control, and other organizations work together to support the Air Force mission. The cadets must also take an aviation course in their final year. Those who are not going to flight training must take AV-460. This course includes two T-43A flights--one similar to AV-100 and the

other a round robin. Cadets medically qualified for Undergraduate Navigator Training must take AV-470 which helps them become "air smart," with three flights in the T-43A. Two of the flights are round robin and the other is a cross country. The positioning aids used for flights are Tacan, radar, celestial, and any combination thereof. AV-471 is an optional course for those cadets who will attend UNT. It includes four flights using the same ATC procedures as UNT. Weekend bases the cadets may visit include Hickam AFB, Bermuda NAS, Beale AFB, Mather AFB, Edwards AFB, and the McDonnell-Douglas Aircraft Company near St. Louis, Mo. These trips give the cadets and the instructor navigators an opportunity to see firsthand how the operational navigator fits into various Air Force missions.

The SIN's job is challenging and time consuming. A SIN must be familiar with all of the aviation science courses, proficient in the cadet procedures for each flying course, and able to instruct cadets as well as critique their mistakes. In addition, the SIN must maintain the same qualification level as any operational navigator and perform primary duties as an instructor or staff officer. This is truly a time management challenge. A study by the Astronautics Department on faculty flying support relayed the following information about SINs. Academic instructors average well over the standard 40 hour week in Academy related activities, and rated instructors average an additional 10-12 hours participating in cadet flying programs. Navigator instructors have 10 two-hour academic classes (trainers) plus about 10 flights a semester. The flights include at least two cross-country missions, Thursday or Friday to Sunday. A navigator also participates in cadet summer programs and is attached to the 50 ATS for one summer period (3 weeks). This appears to be a heavy load, but the cadets' eagerness, the camaraderie and high caliber of fellow officers, and the immense personal satisfaction make the long hours worthwhile.

Being a member of the Dean of Faculty staff plus an instructor navigator gives you the best of both worlds. You can fulfill your career goals and still fly. Since it's important to be a role model for cadets, instructors are encouraged to take on duties outside of the Dean of Faculty. A few of the positions available in the cadet squadron include associate air officer commanding, training officer, professional ethics advisor, squadron participant, and individual cadet sponsor. All these voluntary positions are important to the Cadet Wing. They permit individuals to interact with the three elements of the Academy. Working for both the Dean and the Commandant is not unusual. It is probably the most rewarding situation because you work with cadets on an academic as well as military level.

The Dean also desires that all instructors keep abreast of current trends in their respective fields. He encourages attending short courses, symposiums and conferences as well as presenting research papers. An Air Force Academy assignment can improve basic skills in your specialty and navigation as well as impact the future officer corps.

The climax of an academic year is the rare opportunity to swear in a brand new officer. It is especially rewarding to have watched these individuals mature and develop into the best second lieutenants in the Air Force.

A SIN position at the Academy will be challenging, rewarding, and career broadening. For information on one of the best assignments in the Air Force, refer to AFR 36-20, chapter 8, dealing with special duty assignments. If this assignment is for you, apply now. Most positions at the Academy are forecast at least two years in advance, so plan ahead. For more information call Major Tom Berry, 50 ATS/DO, at AV 259-3790. If I can be of assistance, call me at AV 259-4213.

Via AECP, Capt Krys graduated from the University of Wyoming in 1974 with a degree in Electrical Engineering. He completed UNT and was initially assigned to the C-141 at McGuire AFB. Subsequent tours were at Anderson AFB and McClellan AFB. Capt Krys now is assigned to the USAF Academy.

POLYGONE:

Advanced Electronic Combat Training in Europe

Captain David K. GARRISON
HQ USAFE/DOF
APO NY 09012

The Air Force has long recognized the need to train both strategic and tactical aircrews against the growing number and variety of radar directed surface-to-air defense systems. These systems, mostly supplied and distributed by the Soviet Union, could pose a serious threat to our achieving air superiority in a conflict. Consequently, we now have many electronic combat (EC) training ranges where we simulate those hostile threats to develop effective tactics and countermeasures. Ranges such as Avon Park, Crow Valley, Tonopah, and Sailer Creek are just a few of those areas very familiar to USAF fliers. In the central Europe region, however, EC training is more critical than any place in the world. In this area, the Soviet Union and Warsaw Pact have designed and developed the most extensive and concentrated array of air defense hardware ever known.

A common misconception is that flying in the central region automatically allows aircrews to train against a "dense signal environment" of authentic friendly and enemy threat radars. This is just not the case. For one thing, it's rather difficult to phone an East German or Czechoslovakian surface to air missile (SAM) battery to ask for "play time." Also, our defense systems (i.e., Hawks and Nikes), besides having a wartime mission of their own, cannot realistically simulate the Warsaw Pact emitters. So, in the European central region, the critically needed EC training is lacking. This situation, however, will not last much longer.

POLYGONE ESTABLISHMENT

Within the last several years, developing electronic combat in Europe has been heavily emphasized. Allied nations also realized that EC training was not just a US problem. In April 1979, three nations jointly signed a Memorandum of Understanding (MOU) designed to create an Aircrew Electronic Warfare Tactics Facility (AEWTF) in the European central region. This title has now been changed to Multinational Aircrew Electronic Warfare Tactics Facility (MAEWTF). However, the official name given to the area (due to its shape) is Polygone. A tri-national memorandum for record describes the 1979 MOU:

"The subject Memorandum of Understanding, prepared jointly by representatives of the governments of the Republic of France, the Federal Republic of Germany, and the Secretary of Defense of the United States of America, states that the signatory governments will jointly establish and operate an AEWTF for use by their armed forces. The objective of establishing an AEWTF in central Europe is to realistically simulate a defined section of the electronic warfare threat scenario, including Warsaw Pact air defense electronic systems. The purpose of the AEWTF will be to exercise aircraft equipment and aircrews in the conduct of electronic warfare, develop and test tactics, and evaluate electronic countermeasures equipment capabilities in a realistic electronic threat environment."

Since 1979, an immense amount of work has been done to make the training facility a reality. Polygone opened early this year.

GEOGRAPHIC DESCRIPTION OF POLYGONE

With the signing of the Memorandum of Understanding, the three nations went to work defining the physical boundaries of Polygone. Since 1979, both the size and shape of the area changed several times. Polygone now covers an area located in the northeastern portion of France and stretching into west-central Germany. Bound on the northwest corner by Luxembourg (Fig 1) its geographic center is about 10 nm east of Saarbrucken, Germany. The entire training area is roughly 7,000 square miles. The terrain varies from flat plateau to extremely hilly. This allows

aircrews to face the problem of vulnerability to threats in level areas, and to exploit the advantages of terrain masking in the hilly areas.

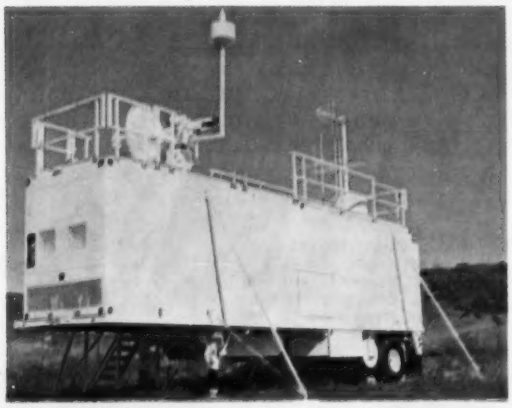
Polygone's central location on the European continent is another plus, since it either encompasses or is very close to user air bases. Therefore, it's not necessary to use a lot of fuel getting to and from the training area.

THREAT SITE EQUIPMENT AND LOCATION

When Polygone opened for training earlier this year, it consisted of four separate threat sites and a Facility Coordination Center (FCC). Each site simulates Warsaw Pact threat radars as well as communicates with the using aircraft and the FCC. Of the four original sites, two are located in France and two in Germany. The French sites are located at Grostenquin and Chenevieres. In Germany, the US provided threat sites are at Bann B and Salzwoog.

Bann B

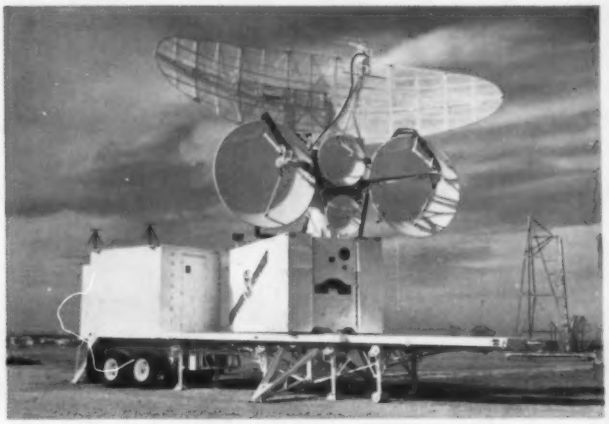
Located four miles directly south of Ramstein AB, this site is not only a threat simulation site but also the location of the Facility Coordination Center (FCC). Primary responsibilities of the FCC are coordinating training times between the using units and providing the all-important aircrew feedback. The FCC is also the communications focal point with direct links to all the threat sites. French Air Force and US Air Force personnel jointly man the FCC. As a threat site, Bann B is equipped with the AN/MPQ-T3 antiaircraft artillery (AAA) radar simulator which provides a realistic signal environment. With computer control, the T3 can replicate the electronic signal of virtually any free world or hostile AAA threat system operating in either E, I, or J-band.



THE AN/MSR-T4, SIGNAL ANALYZER-RECEIVER

Salzwoog

This threat site is 10 miles southeast of the German city, Pirmasens, about 20 miles south of Bann B. The AN/MST-T1A multiple threat emitter simulator (MUTES) and the AN/MSR-T4 signal analyzer-receiver are the primary equipment at Salzwoog.



THE AN/MST-T1A "MUTES," MULTIPLE THREAT EMITTER SIMULATOR

The MUTES can simulate about 60 discrete radar signals including SAMS, AAA, early warning/GCI, and airborne intercept threat radars. The system is computer controlled, allowing software development of electronic combat scenarios, and can track aircraft by IFF, I-band beacon, or optical TV. The MUTES can generate up to five signals at any one time.

The other system, the T4 signal analyzer receiver, evaluates the electronic combat situation and provides aircrew feedback. Using omni and directional antennas, the T4 measures the parameters of the signals provided by the ground-based threat simulator and the signals given by the electronic countermeasures (ECM) response from the victim aircraft. The T4 then compares the two and evaluates the performance of the aircrew's on-board ECM system against the threat. This way the aircrew can determine the effectiveness of the EC systems.

Grostenquin

Situated about 25 miles east of the city, Metz, this French threat site is a decommissioned NATO air base. The runway is maintained which adds to the site's realism by providing authentic target characteristics from the air. Grostenquin is equipped with a AN/MPQ-T3 AAA simulator like the one at Bann B.

Chenevieres

The second French threat simulation site is at Chenevieres, 30 miles south of Grostenquin and 20 miles southeast of the city, Nancy. This facility is similar to Salzwoog in that it is equipped with a MUTES and a T4. Like Grostenquin, it is also a decommissioned NATO air base, thus adding target realism.

THE AN/MPQ-T3 ANTIAIRCRAFT ARTILLERY SIMULATOR

POLYGONE OPERATIONS

Polygone is unique in that it includes portions of two countries with a political border running through the middle. Normally, flying across national borders requires a lot of coordination, special flight planning, etc. This is not so with Polygone. Border crossing procedures are very simple. When a flight is scheduled for Polygone time, the aircraft in that flight can cross from Germany into France as often as they wish and wherever they wish as long as they remain within the boundaries of the area.

Polygone is not a restricted flying area. It is designed for day VFR use. Other VFR traffic, therefore, can be in the area at the same time. Minimum altitude in Polygone is 500 feet AGL. All the normal visual flight rules apply, such as avoiding airport control zones, restricted air space, and populated areas.

Polygone operates six hours a day, five days a week with training scheduled by the FCC. The French and US Air Forces are the primary users. However, Polygone is available to any NATO nation on a fee-paying basis and also supports European exercises requiring electronic threat simulation.

POLYGONE'S FUTURE

Polygone has tremendous growth potential. The United States, France and Germany are already looking at additional threat site locations. Acquisition radars for flight following are being purchased by the United States and France. Also, a network of computers and communications equipment is being developed for real time aircrew debriefing. These are just a few of the programs designed to enhance Polygone's capabilities for the future.

THE OBJECTIVE

To achieve and maintain air superiority, our aircrews must know how to recognize and deal with the growing electronic threat. To do this, training must be as realistic as possible. Polygone's primary objective, developing tactics to defeat the threat, is a critically important task.

In 1974, Capt Garrison graduated from the University of Missouri with a degree in Biology. After OTS commissioning, he completed UNT, EWT and F-4 training before assignment to Kunsan AB. Next came duty at George AFB. Capt Garrison now serves at Ramstein AB.

Navigator EXCELLENCE begins here

Captain Larry A. ECKERT
450 FTS
Mather AFB, CA

The 141 ROTC cadets from across the nation saw this banner statement as they got off the bus to begin their summer encampment. But this would not be your usual ROTC summer camp. These cadets were the cream of the crop--future U.S. Air Force aviators.

This camp, McClellan II, located at McClellan AFB, California, is part of an ongoing process to improve the quality of our navigator force. What is the future of the navigator? What is unique about this camp? Can a camp such as this move us in the right direction? What future improve - ments must be made? Accurate answers to these questions will chart the direction of navigation for years to come.

Times are changing, and so is the traditional role of the navigator. Besides basic navigation, we now must operate sophisticated systems and deliver complex weapons. In the past, navigators could fly one aircraft and easily transition to another. But this is no longer true. The need for specialization is causing us to revamp the training program at Mather AFB, California, and also develop an effective orientation program for navigator candidates.

Photos courtesy John L. Sistrunk, Captain, USAF

McClellan II was designed for future Air Force navigators. Can a camp designed for navigator orientation be successful? Let's look at the McClellan II program and make our own judgment.

For the past seven years, the pilot community has been screening potential Undergraduate Pilot Training candidates during a six-week ROTC summer encampment. Cadets complete the normal four-week syllabus before an additional two weeks of aviation academics and flying experience. The program has been highly successful in reducing UPT attrition and increasing morale--so it was only natural for navigators to try the same type program. But instead of six weeks, the navs had only four weeks to accomplish the same objectives.

The camp was divided into four parts including teamwork, officership, leadership, and navigation. Said one cadet, "I didn't understand when I was told we would undergo 142 percent of the required training, but it didn't take me long to find out."

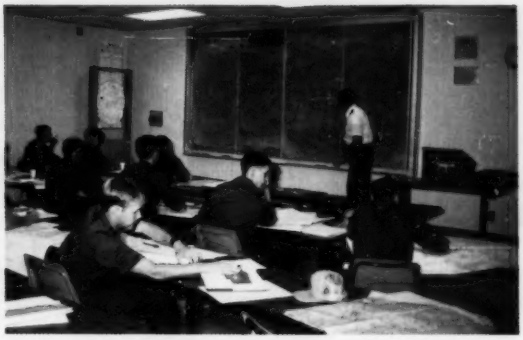
Each day began with a 0520 wake-up, followed by calisthenics and a 1.5 to 2 mile run. This was the cadets' introduction to teamwork. One cadet felt this was the most important aspect of the

camp. The cadets run in groups, encouraging one another to go faster. "It was a unique feeling," said one cadet, "knowing you were not only helping yourself but also developing the team spirit that arises when a group is pushed to its limits. I've never been a person who worked with people. In this environment you're forced to work as a team." To foster the teamwork attitude, cadets were grouped into flights and had weekly competitions involving inspections, drill and ceremony, athletics, and other exercises. All of this combined with problem-solving projects "drilled the teamwork concept into our heads." Why was teamwork stressed? The pilot needs us to find the target and we, as navigators, need the pilot to get us there.

One major goal was developing the minds and attitudes of future rated officers. The concept of "officer first, navigator second" was hammered home through seminars with Air Force officers and senior enlisted personnel. These speakers inspired the cadets to set their goals high when beginning their careers.

The navigation training was the most memorable phase of the entire camp for all cadets. Air Training Command instructor navigators volunteered their time and energy and set up an abbreviated training program. This included classroom academic training, flights in a Cessna 172, T-37, and T-43, and also time in the T45 navigation simulator.

The academic phase was tedious. Cadets studied on the 30-minute bus trip from McClellan to Mather because it was their only free time. Before flying, all cadets had a working knowledge of the MB-4 computer, wind triangle, and basic aircraft systems. But the true test was yet to come--putting this newfound knowledge to practical use.



After two short flights in the 172, the cadets advanced to the T-37. "The light aircraft flew at a snail's pace compared to the 'tweet'," said one cadet. Little did he know--some day he may be tasked with directing an aircraft going three times the speed of the "Awesome Tweet." The T-37 seemed to be the highlight of their flying experience--the first chance to fly in a highly maneuverable jet aircraft. "After 1.4 hours in the air, my backside was numb and my face was sore from a securely fitted oxygen mask, but I felt great! It was all in a day's work and I loved it."

Everything included in the camp was a huge success. The cadets entire perception of the navigator community was altered. Here was a professional aviator ready to meet any challenge head-on and succeed.

But the first navigator camp was not without faults. It was simply too short. Six weeks of training were crammed into four--but the cadets didn't seem to mind. They understood this was a first attempt, and the success and continuation of this program depended on their efforts.

McClellan has many fine facilities but the cadets had to be bussed to Mather, 30 minutes each way, for all the flying training and some of the teamwork projects. Moving the camp to Mather would allow additional training time and exposure to the actual navigation curriculum. This would

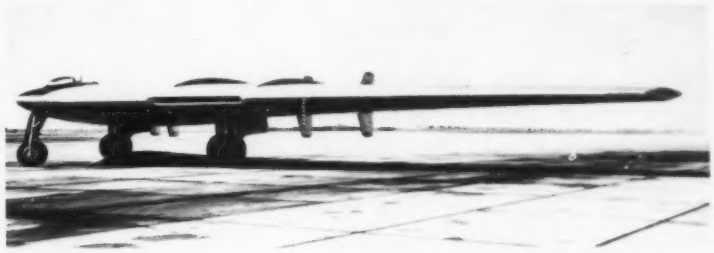
also permit use of the gym facilities including the 1.5 mile improved track and aerobics course.

Finally, the need for more rated field training officers became apparent. The McClellan II officers did an outstanding job. To produce the quality of navigator candidate needed, however, future encampments must consist of officers with navigator experience. An officer familiar with the career field can give the cadets a better understanding of this unique profession.

Since the Air Force navigator's role is changing, we must change our training techniques. McClellan II is the first step in that direction. Its success will not be completely known for two years when the first participants are commissioned and enter Undergraduate Navigator Training. But if the enthusiasm of these cadets is any indication, the training was a huge success--destined to keep the Air Force flying high and showing the way for years to come.

A graduate of Grove City College, Capt Eckert completed UNT in 1978. He was then assigned to the KC-135 at Plattsburg AFB for four years. In 1984, he obtained his master's degree in Systems Management from the University of Southern California. Capt Eckert now serves at Mather AFB.

WINGS of the PAST

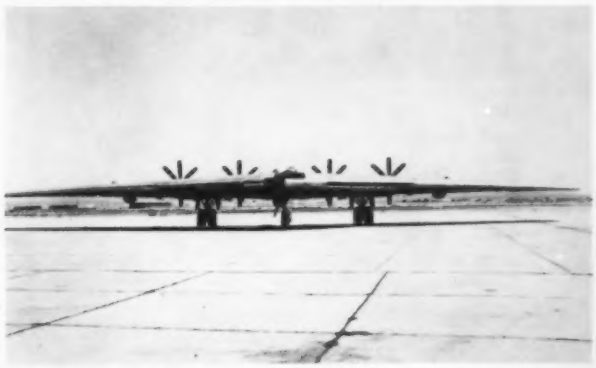


Stealth: The act of moving, proceeding, or acting in a covert way...

Those who have seen the design of the stealth bomber comment on how much it looks like the "Flying Wing." Movie buffs would reflect on a fifties film,"War of the Worlds," where the godless Martians cannot be stopped by conventional methods. We bring out the big guns. "The Flying Wing is going to deliver the bomb," we're told. Then we see it. The silver wing lifts into the air and now we (the viewers) know why it's called the Flying Wing- - that's all it is. There is no visible fuselage and the only hint of verticle stabilization appears to be four small slats which interrupt a great horizontal plane.

Why is this "wing" design suitable for stealth aircraft? Simply stated: the fewer reflective surfaces on an aircraft, the lesser are the chances of detection. Radar reflectivity occurs best at right angles. Vertical stabilizers and fuselage walls are notorious for broadcasting to early warning networks. With no fuselage and very few flat vertical surfaces, a "flying wing" is the obvious choice. Additionally, with today's technology it's possible to produce composite materials that absorb rather than reflect energy.

Obviously, the flying wing design did not come about out of concern for radar concealment. John K. Northrop's first plans for this type aircraft were ready to come off the drawing board in 1929, well before radar was a wartime consideration. He felt too much space was wasted on an appendage linking the wings with



Northrop XB-35, Front View

Photos courtesy 1361st Audiovisual Squadron

Northrop XB-35, In Flight

the pitch and yaw control surfaces. Northrop felt the fuselage was just extra weight. It contributed no lift. Why not build an aircraft that is a complete lifting body? It wasn't until the early '40s that actual construction of Northrop's "flying wing" designs took place.

Northrop wasn't the only one with "wings" in mind. From 1941 to 1954, at least 12 different manufacturers around the globe constructed 18 different "flying wing" jet aircraft. Messerschmitt, DeHavilland, Douglas, Convair, and Avro were among the big names taking a stab at the tailless birds.

The Messerschmitt ME 163B-1 was a single-seat jet fighter built in 1941 that attained a level speed of 623 mph. The Northrop XP-79B was designed specifically for ramming. Built in 1945, its mission was to shear off tail assemblies with its wing leading edges. The pilot lay prone which allowed him to withstand up to 12 Gs during violent maneuvers (like crashing). The AVRO type 698 Vulcan, built in 1953, was the closest thing to an operational "flying wing." Coming on line in the mid '50s, the British Vulcan bomber was still in use in the early '80s.

Northrop YB-49, Photo Session

From 1944 to 1948, Northrop was responsible for four different "flying wing" jet aircraft: the MX-324, single seat jet fighter; the XP-79B, mentioned earlier; the X-4, test airframe for exploring flight characteristics of swept wing tailless aircraft at high subsonic speeds; and the most promising of the Northrop aircraft, the YB-49 bomber. It is the latter that most people visualize when asked about the "flying wing."

Northrop YB-49, In Flight

The YB-49 was a jet powered version of the XB-35. The XB-35 was powered by four eight-bladed coaxial propellers which broke up the smooth lines of the wing. Because the engines were located in the leading edge for more efficient cooling, with the propellers aft of the wing, long drive shafts were required producing an unwanted hidden effect--vibration. Replacing the propellers with jets produced many benefits: decreased vibration, increased power, and smoother lines.

The crew nacelle, located at the center of the wing, was divided into three parts (excluding the tail cone); the forward section containing the flight crew, the crew's quarters having provisions for a relief crew, and the aft gunner's station. The normal crew included a pilot, copilot, flight engineer, radio operator, navigator and bombardier. Space was also provided for two gunners. The complete crew nacelle was pressurized, and personnel could move about while in flight.

The YB-49 was a unique aircraft to say the least. It was a design created by forward thinking individuals who didn't restrict themselves to the conventions of the day. To combine the YB-49 concept with today's alloys, computers, and thrust would be to create a "stealth" aircraft unmatched and unchallenged for years to come.

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